

Time-variable gravity field determination from GRACE-FO data at AIUB

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Content

Kinematic orbits of GRACE-FO satellites

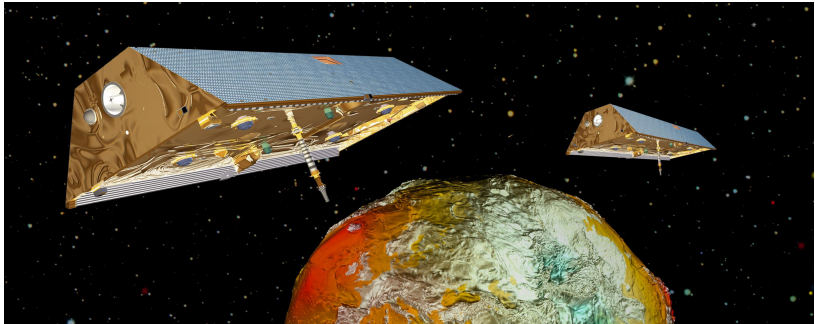
Stochastic behaviour of kinematic positions

Empirical modelling

Inter-satellite link

Impact on gravity field determination

Observations



Credit: DLR

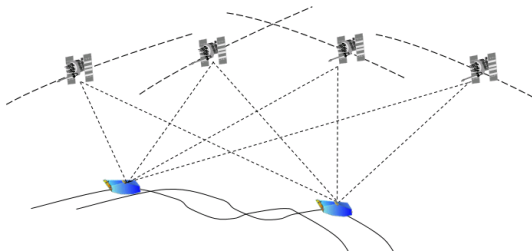
GPS

absolute
3-dim
lower precision

Inter-satellite link

relative
1-dim
very high precision

Kinematic orbits of GRACE-FO satellites



LEO precise orbit determination from GPS data

- 10 s sampling (full sampling used in processing)
- undifferenced PPP solution
- fixing zero-difference ambiguities to integers
- CODE (Center of Orbit Determination in Europe) phase biases
- CODE ambiguity-fixed clocks

Integer-fixing of carrier phase ambiguities

SLR residuals for 2018-11 (in comparison with float)

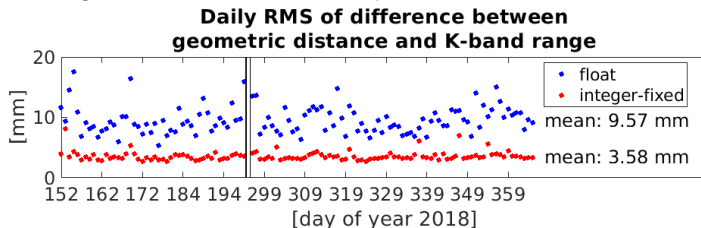
SV	type	mean [mm]	std. dev [mm]
GRACE-C	float	3.1	18.6
GRACE-D	float	-4.5	16.8
GRACE-C	fixed	4.3	10.6
GRACE-D	fixed	1.0	12.0

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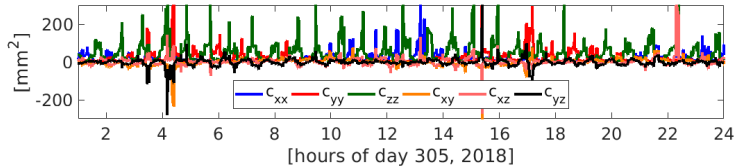
K-band range validation of kinematic positions



→ Individual arcs feature less scattering

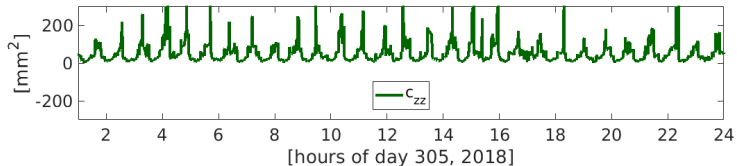
Stochastic behaviour of kinematic positions

- SST-hl tracking geometry varies between poles and the equator
- Epoch-wise covariance information from kinematic PPP: mainly 2/rev; important information on observation quality



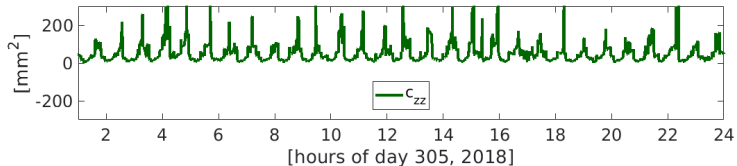
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Stochastic behaviour of kinematic positions

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- Ambiguities feature the correlation between epochs
- Full covariance matrix from PPP (at least in principle)
- Integer-fixed: almost no correlations

Empirical modelling

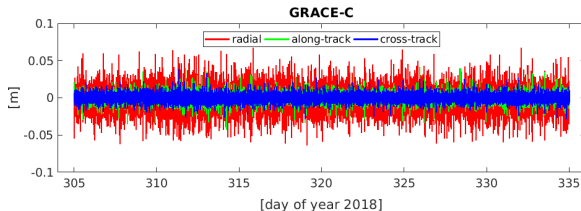
Non linear least squares: $\mathbf{x} = \mathbf{x}_0 + (\mathbf{A}^T \mathbf{P} \mathbf{A})^{-1} \mathbf{A}^T \mathbf{P} \delta \mathbf{l}$

→ The observations enter via $\delta \mathbf{l} = o - c$

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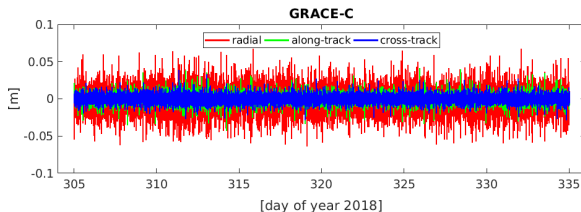
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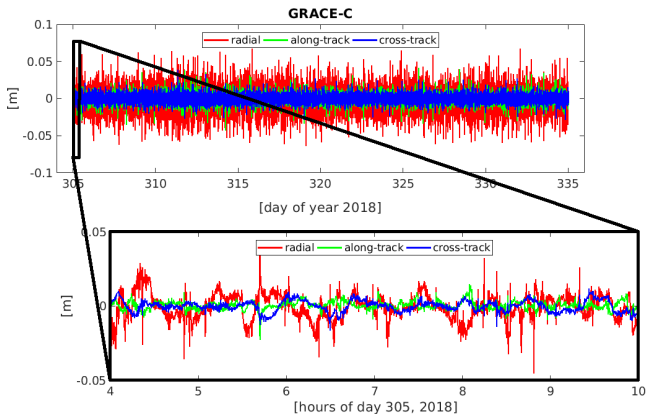


- Residuals feature observation noise (o)
 - And mismodelings from the computed component (c)
- c contains the full a priori force model (gravity field, tides, AOD, accelerometer, ...)

Empirical modelling

Non linear least squares: $\mathbf{x} = \mathbf{x}_0 + (\mathbf{A}^T \mathbf{P} \mathbf{A})^{-1} \mathbf{A}^T \mathbf{P} \delta \mathbf{l}$

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Empirical covariance estimation

- Set up (constrained) piecewise constant accelerations (strategy used at AIUB)

In case of a stationary process

- Estimate a mean covariance function from the residuals \mathbf{e} .

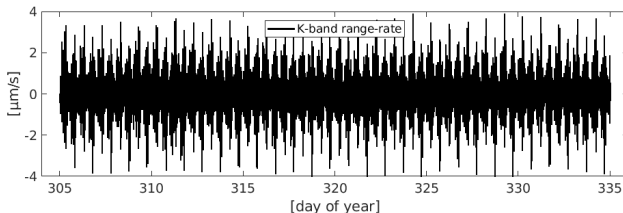
$$\text{cov}(\Delta t_k) = \frac{1}{n} \sum_{i=0}^n \mathbf{e}(t_i) \mathbf{e}(t_i + \Delta t_k)$$

- Variance/covariance matrix has a symmetric Toeplitz-structure and the individual elements only depend on the distance in time.
- Mean covariance function for each month
- Length of correlation 100 min

Inter-satellite link

The inter-satellite link is much more precise

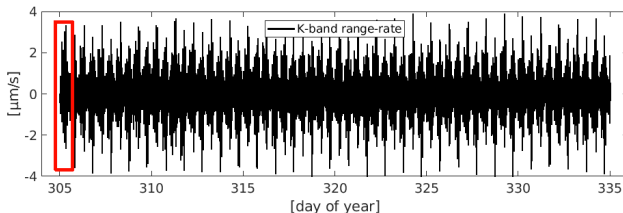
- dominates the resulting gravity field signal
- 5 s sampling for K-band, 2 s sampling for LRI
 - Assign one factor to weight K-band
- extended to weight based on its arc-wise residual RMS
 - Set up constrained PCA to model stochastic behaviour (mainly a 2/rev signal)



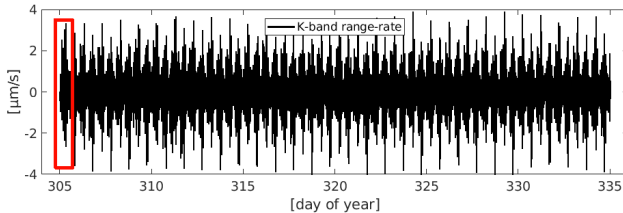
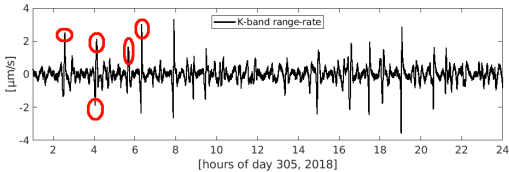
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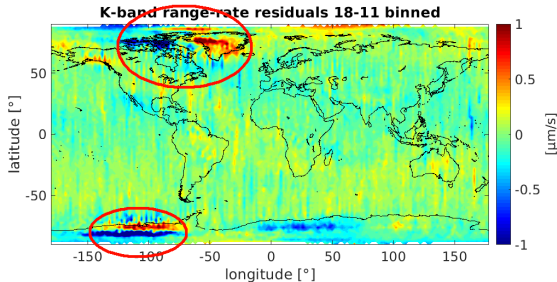
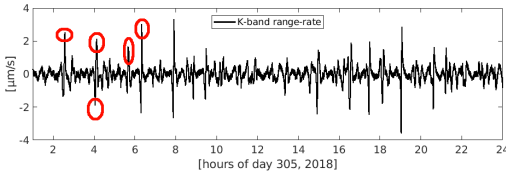
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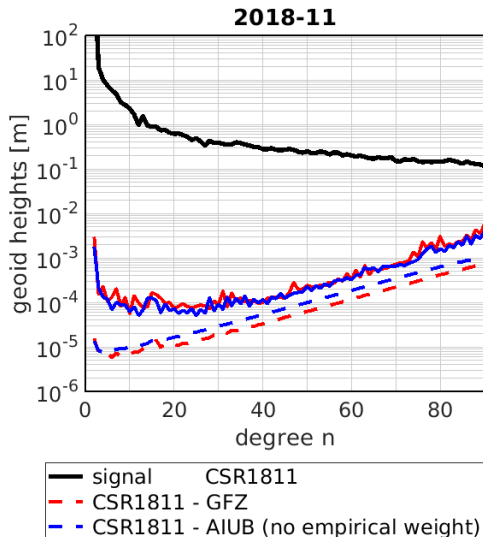


Inter-satellite link



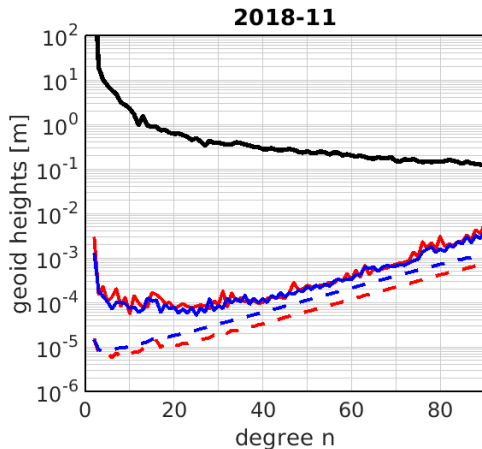
- Large distance in time between reference epoch of background field and observations

Impact on gravity field determination



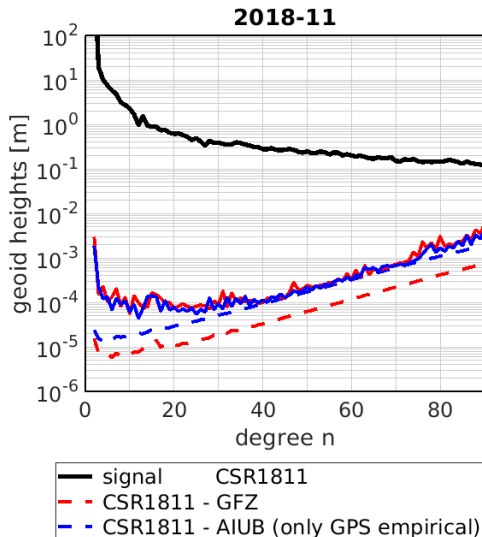
- Formal errors are too optimistic

Impact on gravity field determination



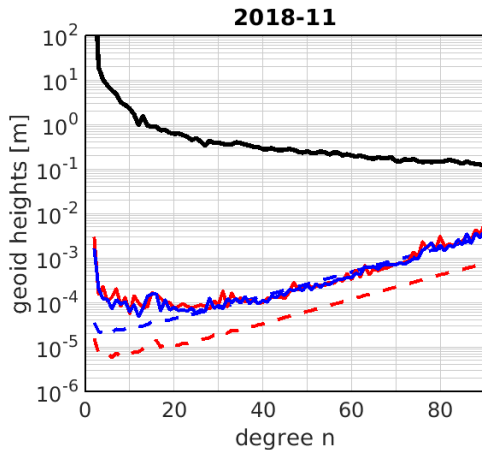
- Slight improvement due to better characterisation of range-rate data
- Noise in background force field modelled through PCA only

Impact on gravity field determination

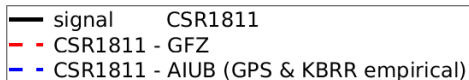


- Noise in background force field mainly characterised due to GPS contribution

Impact on gravity field determination



- Formal errors in higher degrees realistic
- Low degrees require further inspection



Summary

- Integer-fixing of carrier phase ambiguities closer to K-band
- Empirical noise modelling via GPS improves formal errors
- Extend the procedure to K-band/Laser link
- Processing strategy tested on GRACE-FO
- (At some point) reprocess GRACE time series

Thank you for your attention.